

John with those of the same formation in Europe.—On the Wallbridge Haematite Mine, as illustrating the mode of occurrence of certain ore deposits, by Prof. Chapman. The particular mine referred to has been practically worked out, and in the process a clear idea of its character has been gained. It is found to be a "stockwork," or irregular mass, and not, as had been supposed, a vein. Prof. Chapman regards it as typical of a large class of deposits in the vicinity.—On Cambrian rocks of the Rocky Mountains, by Dr. G. M. Dawson. These rocks are the oldest of those shown in the mountains between the 49th parallel and the Bow River. They are of great thickness, and include at one horizon red beds with pseudomorphic salt crystals, sun-cracks, &c. Fossils have so far been obtained from four localities only, and these appear to indicate the horizon of the Prospect Mountain group as olevellites shales of Eureka, Nevada.—On the geology of South-Eastern Quebec, by Thos. Macfarlane.—On the geology of Thunder Cape, Lake Superior, by Thos. Macfarlane. The last two papers were read merely by title, Mr. Macfarlane adding a few explanatory remarks.—Notes on the geology and fossils of Prince Edward Island, by Francis Bain, communicated, with remarks on the fossils, by Geo. Wm. Dawson. The paper contained the results of explorations by Mr. Bain, with mention of fossil plants found by him in different parts of Prince Edward Island. It appeared from these observations and fossils that the red and grey sandstones and shales of which the island is composed are divisible by superposition and fossils into three groups: (1) the Permo-carboniferous as originally established by Sir Wm. Dawson, with local additions made by subsequent observers; (2) a formation regarded by Mr. Bain as probably Permian, and corresponding to the Lower Triassic of Dawson and Warrington's report; (3) an overlying series, probably Triassic, and corresponding to the Upper Trias of the above report. Sir Wm. Dawson discussed the evidence of the fossil plants as bearing upon the above views.

In Sections I. and II. the following (among others of a more or less literary character) were read:—(1) *Population française du Canada de 1608 à 1631*; (2) *A travers des registres du XVII. siècle*, by the Abbé Tanguay.—The manifestation of the æsthetic faculty among primitive races, by Dr. Daniel Wilson. This paper discusses the evidence of the æsthetic faculty, and the practice of imitative art among ancient and modern uncivilised races. The archæological investigations in European prehistoric remains showed a nearly universal absence of imitative art throughout the whole Neolithic period and the subsequent age of bronze. But behind this lay the vastly more remote age of the Cave-men of Southern France, with their singular indications of remarkable artistic skill. This the author compared with such evidences of imitative art as are familiar to us in the work of many native American aborigines, and stated his reasons for tracing all alike to efforts at sign-language and ideographic expression of facts and thought. This was illustrated from an analysis of native Indian languages in their terms for giving expression to the language of art.—Palæolithic dexterity, by Dr. Daniel Wilson. In this paper Dr. Wilson drew attention to the ingenious profile drawings now familiar to us as the products of the ancient Cave-men of Southern France, and showed that by the direction of the profiles they were divisible into right and left-hand drawings. In so far as the examples can yet be adduced, the right-hand drawings are to those of the left hand as about two to one. The percentage of left-hand drawings is thus greatly in excess of what would now be found. But it probably shows at that extremely remote period the bias of prevalent usage which, however originating, has sufficed to determine the nearly universal predominance of the preference for the right hand within the whole historical period.

ON THE OBSERVATION OF EARTH-TIPS AND EARTH-TREMORS

In a paper read before the Seismological Society of Japan on February 15, 1883, I collected together a number of facts which lead to the belief that districts in all quarters of the globe have from time to time been subject to slow changes in level.

Amongst these evidences may be mentioned the changes which have been recorded by many observers in the position of the bobs of pendulums. That pendulums had not always hung in the same vertical line was sometimes indicated by the position of a multiplying index, and sometimes by the position of the

stile of a pendulum as seen through a microscope. Another class of observations have been made by recording the position of a spot of light reflected from a small mirror, the mirror being so suspended that it was caused to turn by the slightest displacement of the pendulum relatively to the earth. A third class of records have been made with horizontal pendulums, the multiplying indexes of which have been observed to move from side to side as if the foundation on which the pendulums rested was being slowly tilted.

A fourth order of observations have been those which have been made with delicate levels, the bubbles of which slowly move along the containing tubes in a manner difficult to explain. A fifth class of records indicating changes in level are those which have been made by observing the displacement of an image reflected from the surface of mercury.

A sixth kind of records are the changes sometimes observed in the levels of lakes and ponds. At the time of great earthquakes, at places remote from its origin, where there was no perceptible motion of the ground, the water of lakes and ponds have been observed to slowly rise and fall as if the basin in which they rested was being slowly tilted.

To the above six classes of records a number of miscellaneous observations might be added, all of which find an easy explanation if we admit that from time to time there are slow tips in the soil.

Another phenomenon which has been observed is that the surface of the ground is from time to time in a state of tremulous motion. These movements have been noted by observing the stile of a pendulum with a microscope, the end of a light multiplying index attached to a pendulum, the quivering and erratic motion of a spot of light reflected from a mirror connected with a pendulum or reflected from the surface of mercury.

An historical account of the various observations which have been made upon earth-tips and earth-tremors may be found in the reports of George and Horace Darwin to the British Association in 1881 and 1882.

Detailed accounts of the observations made in Italy are contained in Rossi's "Meteorologica Endogena."

An account of a considerable portion of the work which has been accomplished in Japan may be found in the *Transactions* of the Seismological Society, in the reports which from time to time I have had the honour of forwarding to the British Association, and in the pages of *NATURE*.

As it seems that these phenomena are gradually attracting an increasing attention, it is my intention in the following notes to give a brief account, not so much of the results I have obtained by observing earth-tremors and pulsations, but of the methods by which these results have been obtained, trusting that my experiences may be of value to those who are desirous of experimenting in this direction.

Among the first instruments I employed were microphones in conjunction with telephones and delicately-suspended short-period light pendulums. From time to time the telephones emitted strange sounds. As to what was the cause of these noises I am unable to say. Unless you kept your ear continually at the telephone there did not appear to be any method of obtaining a satisfactory record, so that, after much labour, these instruments were eventually discarded. For very similar reasons the small pendulums which were often in a state of tremor were also discarded.

The next class of instrument which I employed was similar to an apparatus suggested by Sir William Thomson and used by George and Horace Darwin in the Cavendish Laboratory when experimenting on the lunar disturbance of gravity. Any one who has read Mr. Darwin's account of these experiments will recognise the unusually great care which is required by any one who undertakes to make observations with such instruments. As I was without either assistants or a laboratory, and as my instruments were of the roughest description, my attempts at making satisfactory observations altogether failed. I certainly saw that the spots of light were continually shifting in position, but whether this was due to a tip of the soil or simply to contractions and expansions in portions of my instrument, I was unable to determine.

After much trouble and considerable expense, I very reluctantly gave up the pendulums and mirrors, and sought for apparatus of a still simpler kind. Having accidentally read an account of Plantamour's observations with levels, the simplicity of the apparatus induced me to borrow a pair of astronomical levels from the Imperial Observatory and follow his example.

For a long time these levels were installed beneath cases on a column kindly lent to me by the Professor of Natural Philosophy in the Imperial College of Engineering. Here they remained for over a year, after which they made many journeys. At one time they were nearly 13,000 feet above sea-level on the top of the conical Fujisan. At another time they were some hundreds of feet below sea-level at the bottom of the Takashima mine. These observations attracted the attention of the authorities at the Imperial Observatory, who, recognising the bearing they might have upon work which was going on in the observatory, they supplemented my observations with a second set of levels. All the usual precautions were taken to guard against the effects of temperature, and observations were carried out every three hours both day and night for more than a year. As the books of records accumulated, and the curves grew until some of them were 30 to 40 feet in length, experience showed that the errors chiefly due to changes in temperature might be equal to and even exceed the effects which were being sought. Now, I am inclined to an opinion communicated to me in a letter from M. d'Abbadie, who remarked that two levels upon the same column might be parallel, and yet their bubbles might move in

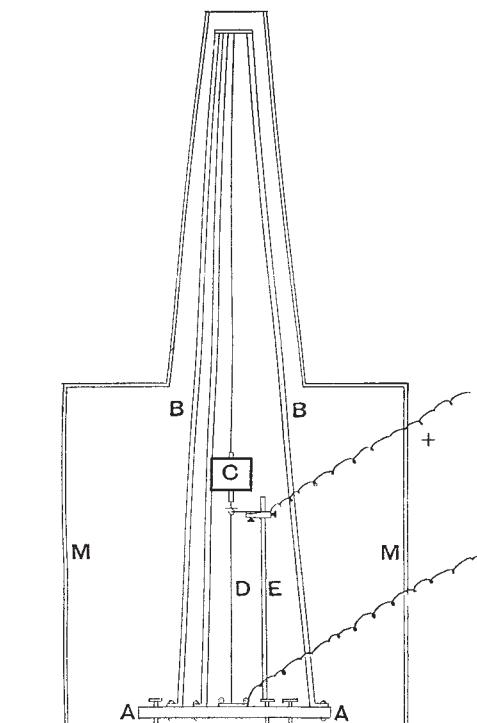


Fig. 1.

opposite directions. Notwithstanding this, the observations of levels have led to some interesting results.

First, there is the fact that level bubbles may wander without there necessarily being a change of level. Second, that level bubbles continue to move long after the sensible motion of an earthquake has ceased, thus giving us a means of observing the movements of long periods which usually bring the phenomenon of an earthquake to a close. After the earthquake the bubble will sometimes take up a position slightly different to that which it had before. Changes in the position of bubbles have been observed a short time before some of our earthquakes. Another result is the fact that the greatest irregularities in the curves showing the position of the bubbles of a level occur when earthquakes are most numerous. This is during the winter months. A last result is the fact that during a typhoon, or when the barometer is unusually low and fluctuating, a level bubble may be distinctly seen to pulsate through a small range, as if there were continuous changes of level going on.

While working with the levels another kind of instrument which I employed was a pendulum suspended from an iron

stand, and so arranged that its stile could be viewed in the field of a microscope. By placing a prism beneath the end of the stile, the image of its end could be looked at horizontally, and the motion of the pendulum could be seen in any azimuth. At first I employed two microscopes placed at right angles, but by the adoption of the prism one microscope became sufficient. With these instruments, which are similar to those employed by Messrs. Bertelli, M. de Rossi, and other Italian observers, I verified for myself some of the more important results which had been noted in Europe.

For instance, it was seen that the pendulum was seldom at rest. Storms of tremors would take place with a low barometer. The pendulum did not always vibrate over the same point. It appeared as if there had been a tip in the soil, and the stand of the apparatus had been slightly inclined. These, together with other results which in many respects are little more than repetitions of results obtained by Bertelli, Rossi, and other observers, I have already published. Without attempting to describe other experiments which I have instituted, I will now give a brief description of an instrument which has been reached gradually, and which has given me the greatest satisfaction. From a letter received from M. d'Abbadie, whose researches regarding the change of vertical are amongst the most important yet instituted, I learn that my instrument has many points in common with one employed by M. Bouquet de la Grye. When I first set up this instrument, it was simply as a contrivance intended to make electrical contact, and set certain machines in action at the time of an earthquake. I next employed it as an instrument to record the occurrence of slight earthquakes. In its third form it was used to indicate earth-tremors and devia-

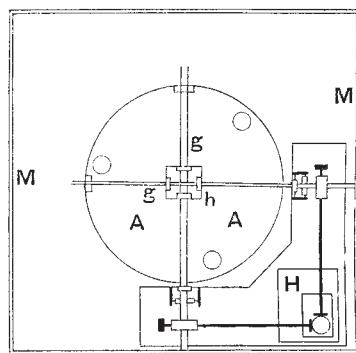


Fig. 2.

tions in the vertical. It will be readily understood from the accompanying sketches, Figs. 1 and 2: A A is a circular disk of cast iron about $\frac{3}{4}$ inches in thickness, resting on levelling screws. Bolted to this is a tripod of angle iron about 5 feet high, B B. This forms the support for a pendulum, c. The bob of this pendulum weighs about 7 lbs. It is made of a brass tube (3 m. diameter and $2\frac{1}{2}$ m. long) filled with lead. This is carried by a fine iron wire 3 feet $3\frac{1}{2}$ inches long, soldered into a small hole in a plate at the top of the tripod. A spike, c, projects from the base of the bob (see Fig. 3). As the bob with its spike were turned in a lathe, the end of the spike, the point of support and the centre of figure of the bob are fairly in a straight line.

A long, light pointer, D, made of a strip of bamboo which has been varnished, is kept in contact with the base of the pointer, as shown in Fig. 3. At the top of the pointer there is a light brass ring, e; at the top of this there are two fine needle-points, a and b. The point a is kept in contact with the base of the pendulum by turning the screw T, which raises the flat spring s on which b rests. T is carried by a strong stand, E, which rests at three points on A; f f is a disk of lead which is nearly equal in weight to that of the pointer below b.

In one instrument a b is 6 mm, whilst the total length of D is 415 mm. With these dimensions we may suppose that if the base pendulum moved, say, 1 mm., then the lower end of the pointer would move about 68 mm. The values to be given to the deflections observed in the pointer have also been estimated by giving a slight turn to one of the levelling screws of the base plate, and thus tipping the plate through a known angle.

Records were at first made by reading a scale of millimetres placed beneath the end of the pointer. Experience showed this method to be inconvenient and without satisfaction. What occurred between the hours of observation was unknown, whilst the records which were made were liable to greater or less errors due to the observer. This led me to seek for some method which would render the observations automatic. To attach a hair to the end of the pointer and let it be dragged across the surface of a smoked glass created too great friction. The necessary appliances for photographic registration were too costly and too troublesome to be employed as I was situated in Japan. A very near approximation to frictionless registration was obtained by sending a current down the pointer, the end of which trailed on the surface of a thick film of iodised starch covering a strip of paper. The strip of paper, which was on a metal tray, moved slowly by clockwork beneath the lower end of the pointer. On taking out the paper I found that the film of starch, with its blue line, could be dried down to form a brown line on the paper. The process was troublesome and the line subject to distortion by the flow of the starch. The next idea was to discharge a spark from the end of the pointer and perforate a band of paper moving beneath the end of the pointer at the distance of about 5 mm. This feature in the apparatus, M. d'Abbadie writes me, is an essential feature in the apparatus of M. Bouquet de la Grie. To avoid losing a record, should the pointer move parallel to the length of the paper, two bands of paper, *gg*, moving at right angles (by means of the clock, *H*), are employed (Fig. 2). One band passes beneath the other over the surface of a brass plate, *h*. The paper used is the ordinary paper employed in a Morse telegraph instrument. By allowing the hand of a clock to pass every five minutes across a wire the current from two of Thomson's tray-cells is sent through an induction coil which yields the sparks to perforate the paper. Every hour the hand of the clock makes a long contact by

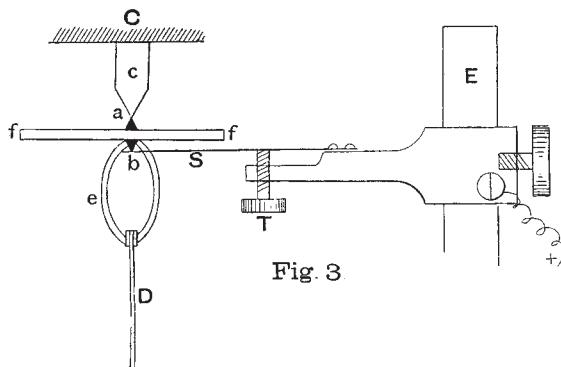


Fig. 3

passing across a small strip of platinum. In this way a large hole is made in the moving bands of paper and the hours are recorded.

To secure myself against error the same secondary current which perforates the paper of one machine is carried by wires to perforate the paper of a second instrument of slightly different construction placed on a stone column in a distant room.

The only work required is to wind the clocks which pull the paper and the clock which makes the contacts. This being done, records are automatically made every five minutes.

Up to the present the records which have been obtained have not been analysed, but certain of the results which they indicate are evident. These are as follows:—

1. Sometimes for days the pointers remain stationary, as is indicated by the sparks being regular and in a straight line (see Fig. 4).

2. Sometimes the pointers are in a state of tremor, and the sparks perforate the paper at many points, giving a line of several millimetres in breadth (see Fig. 5). These tremors may continue for ten or twelve hours. From the diagram, the duration of these tremors and the range of motion can be accurately measured. The instruments in both rooms agree as to the occurrence of tremors and periods of rest.

3. Sometimes the pointer will slowly wander from the straight line, and then slowly return. This usually takes place two or

three times in succession. It would seem as if the ground had been slowly tipped through one or two seconds of arc, the period of each tip being from fifteen to sixty minutes (Fig. 6).

In regard to the occurrence of these tips, the instruments in the two rooms only occasionally coincide.

As to whether they are really to be regarded as true disturbances of level, or simply as movements due to local causes, I shall be better able to speak after a more careful examination of the records.

4. Sometimes I find the bands of paper perforated over their whole breadth by sparks in all directions. This indicates that an earthquake has occurred and the pointer has been swinging (see Fig. 5, about 9.15 p.m.). All these figures have been produced by pricking through from the original diagrams. The clocks which I have used are made from small American spring clocks costing in Japan about 12s. each. The total cost of the portion of the apparatus figured, including the case, *M*, the doors of which and the parts which come in contact with the column are edged with flannel, is about 25 yen, or £4 10. In Europe an instrument of better construction would cost more. One of the columns on which an instrument is placed measures 6 feet by 3 feet and 5 feet high. It is constructed of brick and rests on concrete. The other column, which also rests on concrete, is made of stone. It measures 2 feet 2 inches \times 2 feet 2 inches and is also 5 feet in height.

This latter column is rather too slight, as I found that even the pressure of my thumb is sufficient to cause the pointer of the instrument to move several millimetres.

Amongst those who may possibly have a practical interest in this matter are those who have to deal with mines—especially, perhaps, coal-mines.

In the columns of the *Japan Gazette*, in *NATURE*, in the *Mining Journal*, and other papers, references have been made to the attempt to observe earth-tremors and other phenomena in the Takashima Colliery near Nagasaki. At the conclusion of a

4 3 2 . . .
February 24th. 2-4. A.M. (No movement)
Fig. 4

6 7 8 . . .
March 28th. 1885. 6 & 7. P.M. (An earth tip?)
Fig. 6.

10 9 8 . . .
March 16th. 1885. 8-10. P.M. (Tremors & Earthquake)
Fig. 5.

report to the British Association, 1884, on the earthquakes of Japan, a letter from Mr. John Stoddart, the chief engineer at that mine, tells us that, owing to the working of the mine and other causes, he finds it impossible to make observations with delicate instruments. He therefore proposes to move the instruments to some distant station, assuming that any natural cause which would cause tremors in the mine will be generally felt over a considerable area. As to whether there is a connection between earth-tremors and the escape of gas in collieries, we do not yet know. Mr. Walter Browne, in a paper to the North of England Institute of Mining and Mechanical Engineers, thinks it desirable that investigation on this subject ought to be made, and quotes what is being done at Takashima. Mr. Galloway, writing in *NATURE* of February 5, if I read him correctly, does not encourage Mr. Brown's suggestions, and enters into an argument about the possibility of an earth-tremor forming a fissure. Earthquakes often form fissures on the surface, but these effects in mines are usually nothing. I make this statement on the authority of personal inquiry in many mining districts.

With the exception of the disturbances near an epicentrum, the movements due to ordinary earthquakes are so superficial that the range of motion at the depth of 10 feet is sometimes only one-fortieth of what it is at the surface. Earth-tremors are phenomena usually lasting many hours, and they certainly occur with low barometers. That they could by any possibility form fissures it is difficult to imagine.

As to what may be the cause of earth-tremors I am not prepared to offer a definite opinion; but, inasmuch as their association with barometric fluctuations renders it possible that in their occurrence they may also be associated with the escape of fire-damp, about which we have so little knowledge of practical value, it seems impossible that their study should be neglected.

Whether the results of such a study would be of practical value to the miner is not known, but that results of scientific value would be obtained is indisputable.

As the making of such observations are neither a matter of trouble or serious expense, I sincerely trust that they may be undertaken. On some future occasion I hope to describe the experiments which I made with one of these instruments on the summit of Fujiyama (13,365 feet), where movements were of a very marked and decided character.

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JOHN MILNE

SOCIETIES AND ACADEMIES

LONDON

Royal Society, June 18.—“The Removal of Micro-organisms from Water.” By Percy F. Frankland, Ph.D., B.Sc., F.C.S., Associate of the Royal School of Mines.

The author has investigated the efficiency, as regards the removal of micro-organisms, of methods of water-purification depending upon

- (a) Filtration
- (b) Agitation with solid particles
- (c) Precipitation.

The method of investigation consisted in determining the number of organisms present in a given volume of the water before and after treatment, the determinations being made by Koch’s process of gelatine-culture on glass-plates.

Treatment of Water by Filtration.—The filtering materials examined were greensand, silver sand, powdered glass, brickdust, coke, animal charcoal, and spongy iron. These materials were all used in the same state of division, being made to pass through a sieve of 40 meshes to the inch, and in columns of 6 inches in depth. The following results were obtained:—

	No. of organisms in 1 c.c. of water before filtration	Ditto after filtration
Greensand	80 ...	0
ditto (after 13 days)	8,193 ...	1,071
ditto (after 1 month)	1,281 ...	779
Silver Sand	11,232 ...	1,012
Powdered Glass	11,232 ...	792
Brickdust	3,112 ...	732
ditto (after 5 weeks)	5,937 ...	406
Coke	3,112 ...	0
ditto (after 5 weeks)	5,932 ...	86
Animal Charcoal	very numerous ...	0
ditto (after 12 days)	2,792 ...	0
ditto (after 1 month)	1,281 ...	6,958
Spongy Iron	80 ...	0
ditto (after 12 days)	2,792 ...	0
ditto (after 1 month)	1,281 ...	2

Thus greensand, coke, animal charcoal, and spongy iron were at first successful in removing all organisms from the water passing through them, but after 1 month’s continuous action this power was in every case lost, the improvement still effected, however, by spongy iron and coke was very great indeed, whilst the greensand and brickdust were much less efficient, and the number of organisms in the water that had been filtered through animal charcoal was greater than in the unfiltered water.

Treatment of Water by Agitation with Solid Particles.—Water was agitated with various substances (in the same state of division as above) and after the subsidence of the suspended particles, the number of organisms in the water before and after treatment was determined. 1 grm. of substance was in nearly each case shaken up with 50 c.c. of water. The agitation was in nearly all cases continued for 15 minutes, but the duration of subsidence was varied according to the length of time which it required for the water to become clear. The following results were obtained:—

	No. of organisms in 1 c.c. of water before treatment	Ditto after treatment
Spongy Iron (1 minute agitation, $\frac{1}{2}$ hour subsidence; 5 grms. used)	609 ...	28
Spongy Iron (15 minutes’ agitation, $\frac{1}{2}$ hour subsidence; 5 grms. used)	609 ...	63
Chalk (15 minutes’ agitation, 5 hours’ subsidence)	8,325 ...	274
Animal Charcoal (15 minutes’ agitation, 5 hours’ subsidence)	8,325 ...	60
Coke (15 minutes’ agitation, 48 hours’ subsidence)	Too numerous to be counted	0
China Clay (15 minutes’ agitation, 5 days’ subsidence)	—	Too numerous to be counted

In order to ascertain whether subsidence alone would diminish the number of organisms contained in the upper strata of water, bottles containing infected water were allowed to remain at perfect rest, and then the upper layers in the several bottles were tested for organisms at different intervals of time. Thus:—

Hours of rest	No. of organisms found in 1 c.c. of water
0 ...	1,073
6 ...	6,028
24 ...	7,262
48 ...	48,100

Thus, without agitation with solid particles and subsequent subsidence of the latter, there is no diminution, but on the contrary an increase in the number of organisms in the upper strata of water.

Treatment of Water by Chemical Precipitation.—The effect of “Clark’s process” in removing organisms from water was investigated both in the laboratory and on the large scale. In the laboratory experiments the following results were obtained:—

Organisms in 1 c.c.
Untreated water
ditto (after 18 hours’ rest)
Water after Clark’s process and 18 hours’ subsidence
42

In a second series of experiments the following results were obtained:—

Organisms in 1 c.c.
Untreated water
ditto (after 21 hours’ rest)
ditto (after 48 hours’ rest)
Water after Clark’s process and 21 hours’ subsidence
22
ditto (after 48 hours’ subsidence)
166

On the large scale the efficiency of the process was examined at the Colne Valley Waterworks, Bushey:—

Organisms in 1 c.c.
Hard water
Water after softening and 2 days’ subsidence
322
4

A recent modification of Clark’s process devised by Gallet and Huet was also examined:—

Organisms in 1 c.c.
Hard water
Soft water
182
4

Thus a very great reduction in the number of organisms present in a water may be effected by submitting it to Clark’s process. It appears also that the clear water should be removed as rapidly as possible from the precipitated carbonate of lime, as otherwise the organisms may become again distributed through the water.

Micro-organisms in Potable Water.—The number of organisms in natural waters of various origin has been determined by the author, who appends the results of a monthly examination, in this respect, of the various waters supplied to London during the first three months of the present year:—